Silicon Based Microchemical Concepts for Miniature Fuel Processor

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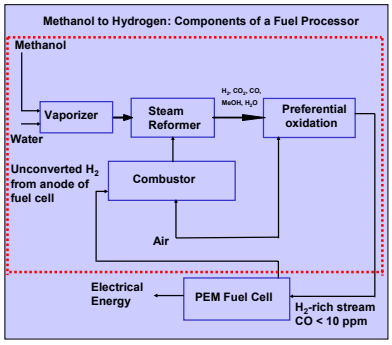
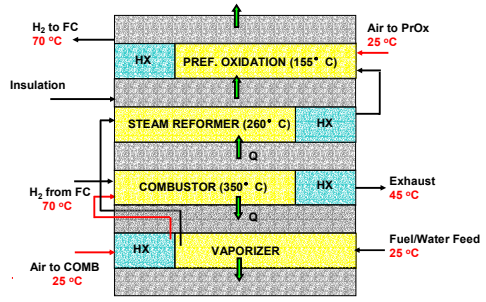
The success of PEM fuel cell technology vastly depend on the development of an easy & efficient way to deliver the fuel to the cell. Since on-board storage of hydrogen is not safe & efficient, an on-board fuel processor that can produce hydrogen in-situ from liquid methanol or other hydrocarbons is an attractive source of hydrogen for portable fuel cell. High purity hydrogen generation for an onboard power demands the fuel processor to be compact, lightweight, & inexpensive. The microtechnology based fuel processor can meet this demands. Silicon based microchemical systems present opportunities for miniature on-board fuel processing and micro fuel cell for portable power generation.

Design, fabrication, packaging, and integration of fuel processing components is the most challenging & integral part of this research program. The unit will convert methanol to hydrogen with less than 10 ppm CO to fuel a PEM fuel cell with an electrical output of 20 We.

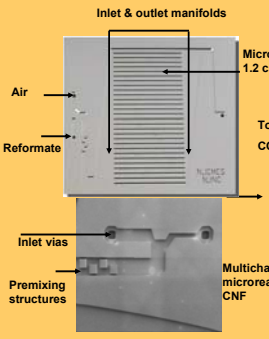


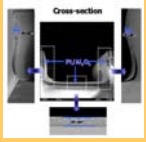


CONCEPTUAL INTEGRATION OF FUEL PROCESSING COMPONENTS

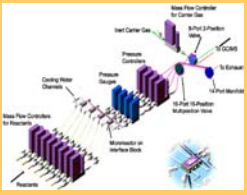
PREFERENTIAL OXIDATION OF CO

The steam reforming process produces CO as by-product in appreciable amounts, which should be reduced below 10 ppm in order to prevent poisoning of the Pt-based catalyst of the PEM fuel cell. Preferential oxidation (PrOx) of CO in the reformate stream can be employed as the final CO clean up step to low ppm levels tolerable to PEM fuel cells.





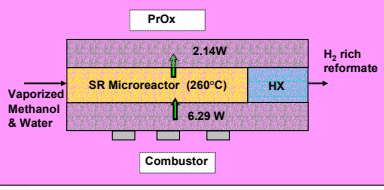
Cross-section of the microchannel with thin film Pt/Al2O3 catalyst coating

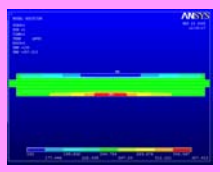


- As a key fuel-processing component, multichannel silicon PrOx microreactor have been successfully designed, fabricated, and demonstrated
- Silicon MEMS technology used to produce PrOx reactors with microscale geometry having high aspect ratio
- Thin film of sol-gel synthesized metallic Pt catalyst on porous support Al_2O_3 successfully coated on microchannel walls
- Microreactors were characterized in a microkinetic array test rig. 100 % CO conversion achieved at 280° C, with 40% selectivity for CO oxidation reaction in hydrogen rich reformate gas.

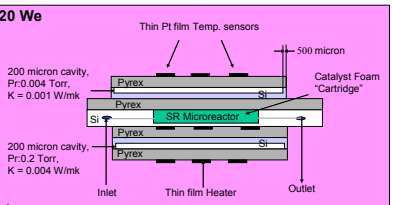
Microkinetic Array Test Rig for Characterization of Microreactors

Integrated Micro Steam Reformer (SR) for 20 We



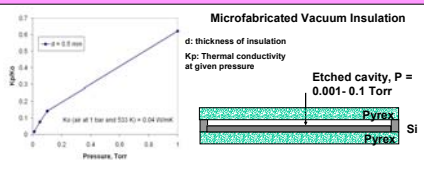


ANSYS Thermal Simulation of Insulator Packaged with SR Microreactor



Micro Steam Reformer Integrated with Vacuum Insulation, Thin Film Heater & Temperature Sensors

Microfabricated Vacuum Insulation



- Insulation plays critical role in thermal integration of fuel processing components. It should minimize heat losses to environment and isolate high temperature units from low temperature ones.
- Vacuum packaging of microreactor can be an effective way of insulation. Microfabricated cavity surrounding the reactor filled with low pressure gas offers very low thermal conductivity down to 0.001 W/mK
- Compatible with silicon microfabrication (anodic bonding under vacuum)

Summary: As a key fuel processing components, PrOx & SR microreactors are designed & fabricated with emphasise on thermal integration of overall unit. Silicon micromachining is an attractive route for microreactor fabrication. Silicon microchemical systems find applications in small scale power generations as it enables stacking of fuel processor & fuel cell components on a chip for compact, lightweight power generation.

Acknowledgements: Picatinny TACOM/ARDEC, DARPA, NJCST, CNF Staff especially Michel Skvarla & Rob Ilic